Reengineering in the aircraft industry using business process modelling

Randolf Isenberg
Daimler-Benz Aerospace Airbus
21111 Hamburg, Germany
Tel.: ++40-7437-4166

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Introduction

Like other industries, the aircraft industry is under high pressure to meet drastically increased customer goals for market price and flexibility. This while at the same time share holders request for short term profit guarantees. Daimler-Benz Aerospace Airbus has met this challenge using business process reengineering methods which led to total company restructuring from functional orientation to customer and product orientation.

This paper will show how business process modelling techniques have been applied. Especially concurrent engineering methods are used to integrate the various disciplines involved from market analysts over design, commercial to industrialization staff.

It is mainly the balance between centralization towards product and customer identification and at the same time distributed operationalization of processes leading to autonomous centers of competence.

The next chapter will shortly review business process reengineering, organization theoretical aspects and concurrent engineering as a basis for the concepts presented.

Business process modelling in aircraft industry starts with a problem analysis. From this a business process concept for customer and product orientation is derived. Using the basic principles of concurrent engineering, a solution for integration functions over business processes is presented and the necessary changes to planning and controlling the economical aspects of the product.

State of the art

This chapter will shortly review some research topics, namely business process reengineering, organization theory and concurrent engineering which are relevant for the application example in aerospace industry.

BPR

Business process reengineering BPR [Hammer et al. 93] is essentially value engineering applied to the system to bring forth, sustain, and retire the product, with an emphasis on information flow. By mapping the functions of the business process, low value functions can be identified and eliminated, thus reducing cost. Alternatively, a new and less costly process, which implements the function of the current process, can be developed to replace the current one.

A basic feature of these optimized business processes lies in their potential flexibility in response to changes in their environment.

Another definition for Business Process Redesign is "the analysis and design of workflows and processes within and between organizations" [Davenport et al. 1990].

However there are early warnings such as that, as typically implemented, BPR drives fear into the organization and destroys the social dimension of the sociotechnical system which produces the product or service. Under these conditions, BPR will lead to a reduction in value to the customer and hence to a reduction in the value of the enterprise [Deming, 1986]. [Lalli 1996] cites convincing evidence that downsizing reduces the long term value of a company´s shares unless considerable effort is put into training the employees left, and thus treating them as valuable assets.

BPR implementation is usually guided by consulting companies to avoid the biggest obstacles, i.e.

- lack of sustained management,
- unrealistic scope and expectation and
- resistance to change.

However, it is questionable whether for each company a unique process organization has to be developed. It is much more efficient to concentrate on the main functions and for the rest adopt reference processes extracted from a variety of consulting projects [Scheer 94]. This computer-based description of reference models for reengineering business processes affords valuable assistance during business process reengineering. Another problem during BPR realization is the management of huge amount of information while analysing and designing the processes. The ARIS-Toolset [Scheer 94] is an integrated environment for developing, navigating and analysing business models.

Organization theoretical background

The basic concept of organization theory has already been adopted in enterprise modelling since 1981 [Fox 81]. Modelling on the one hand side helps understand the functioning/ malfunctioning of systems and serves as well as a shared database providing a well defined terminology of an enterprise [Fox et al. 93]. A logical framework for enterprise modelling under different perspectives, e.g. for activity based costing can be found in [Gruninger et al. 94], [Fox et al. 95]. In [Isenberg 90] an organization model for CIM Computer Integrated Manufacturing is derived from an organization theory including a process, product and ressource model which are implemented at shop floor level.

There are two main problems to be solved while defining an organization model, i.e. the reduction of complexity and uncertainty.

While complexity is reduced by an optimized structure of the enterprise, the uncertainty is handled by its control principles. However structure and control are interdependent, so that with a good structure, the control effort can be reduced as well. Figure 1 further subdivides the structure in task structure, coordination structure and information structure.

The task structure represents mainly problem partitioning, e.g. a hierarchically decomposition bringing about a set of less complex problems. The coordination structure takes care of the interdependencies between the members of this set. Whereas the information structure shows the necessary information flow between members.

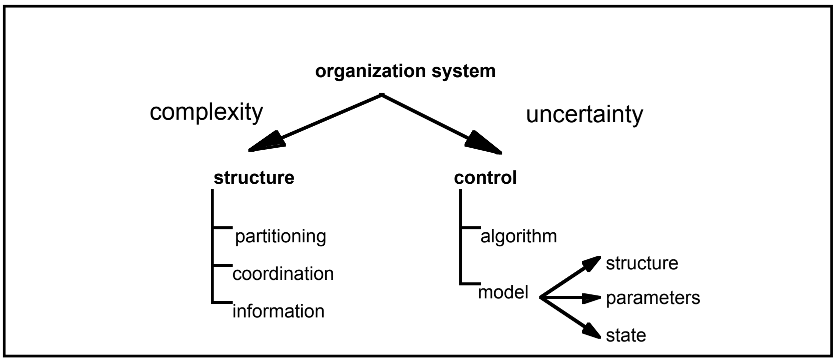

Fig. 1: Design components of an organization

The design of control has the goal to minimize the uncertainty by specifying control algorithms and the underlying world model which describes the structure, parameters and states of the enterprise. Basically it is assumed that with no uncertainty about the world model, no control should be necessary. For practical applications it is very important that the uncertainty in control algorithms and the world model should be remembered as well. Analytic algorithms are available only for quite simple models of the real world, so that for complexer models, heuristic knowledge is used.

In this paper, the organization theory view will be used to describe the organizational changes from functional to product management organization in Daimler-Benz Aerospace Airbus.

Concurrent Engineering CE and Computer Supported Cooperative Work CSCW

Concurrent Engineering CE and Computer Supported Cooperative Work are both answers to the problem of integrating specialists towards an overall enterprise task. However, they differ in their focal point.

CSCW [Mc Carthy 94] focuses on the cognitive and interpersonal aspects of group work such as personality, skill-level and expertise.

CE [Reddy et al. 93] is the attempt to support different stakeholders such as market analyst, designers, industrialisation and commercial specialists by enabling cooperation during product development. CE emphasizes response to customer expectations and embodies team values of cooperation, trust, and sharing in such a manner that decision making proceeds with large intervals of parallel working by all life-cycle perspectives, synchronised by comparatively brief exchange to produce concensus.

While team work has been acknowledged as an effective approach, wide-scale adoption of this approach proved to be difficult due to the rigid hierarchical structure of our organizations and the lack of tools that enable real-time communication among team members working in heterogeneous, geographically distributed environment. To overcome the barriers, the notion of a tiger team is proposed by the DARPA (Defense Advanced Research Projects Agency) Initiative in Concurrent Engineering (DICE). These are interdisciplinary teams that are physically collocated in order to enable concurrent product development. In addition, a so-called virtual tiger team is introduced to extend the approach for locally scattered teams of experts who collaborate using a computer supported collaborative environment over the network.

Business process modelling in aircraft industry

Problemanalysis

The competitive market and the net income situation of the company were the main driving factors to start a business reengineering project. To achieve at the same time reductions in cost by more than 30%, leadtime up to 50% and a drastic increase for customer flexibilty was not possible using the normal cost reduction procedures [Tijssen et al. 96].

At the starting point of the business reengineering project, the **structure** of the organization was a typical functional hierarchy (Fig. 2). Using the notation of [Fox 81], the **partitioning** was achieverd according to functions such as aerophysics or electrical system development. To reduce the complexity, functional groups have been defined. The **coordination** is hierarchical and centralized per function or function group, i.e. the main effort is on optimizing the functional knowledge over several product programs. This facilitates at the same time manpower balancing. The **information** as well was centralized per function group.

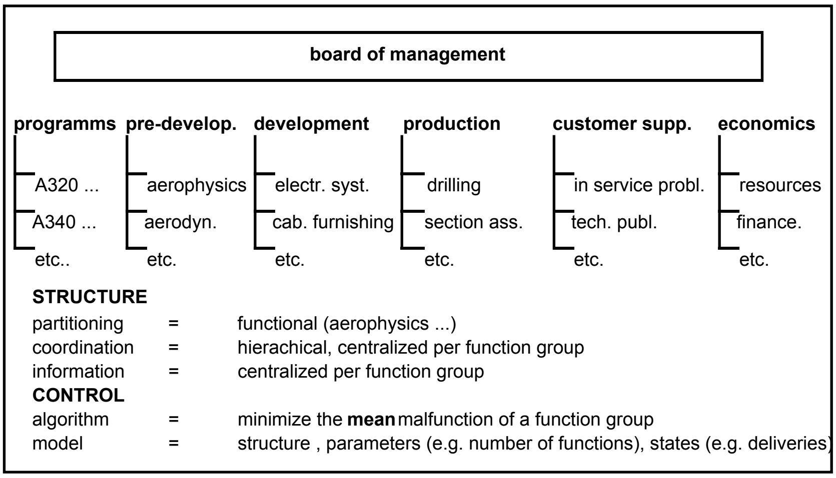

Fig. 2: The functional organization

The **control** was characterized by minimizing the **mean** malfunction of a function group, i.e. if the percentage of lead time increase or cost increase was kept under a limit the functional group was regarded as working sufficiently well. The **problem** was that a functional group head did not have the overview about the result of his optimization for a single customer order and its path through the whole enterprise. It may be that a small delay for a specific order has a much severe impact on the total customer delivery delay than a large delay for another order of his work load.

Another disadvantage of such an organization is that it handles routine jobs with the same complex procedures/processes as highly sophisticated development tasks.

Concerning the seperated economic function, economists tend to think they are the only ones who are responsible for the economical situation of the enterprise. This is one reason why engineers tend to optimize according to technical criteria rather than looking together with the economist for a technically and economically sound solution for the whole life cycle.

The analysis at Daimler-Benz Aerospace Airbus was supported by the consulting company Diebold [Tijssen et al. 96]. After defining the main project goals, an analysis of 100% of manpower for the relevant functions was performed. It revealed the possible regions for improvement which were later on investigated with a detailed process analysis for possible optimization. With the project goals, a set of main processes with strict process orientation have been identified and a process-owner from top management has been assigned. Basically, the processes were derived from the life-cycle phases of a product, i.e.,

A Product development/prototyping,

B Series production

C After sales

With his center-team the top-manager was responsible for achieving the goals in his main process. After defining the main concepts, realization projects were defined and a detailed control of goal achievement started.

Concept for Customer and Product Orientation

The most important conceptual idea was to restructure the enterprise from a customer- and product-oriented view point. Therefore the formerly functionally oriented company was "horizontally" divided into its major product lines, taking into account technical aspects as well as its actual point in the life cycle. For the Airbus products these were:

- Single Aisle: A319, A320, A321 the single aisle Airbus in the middle of its life cycle,
- Long Range: A330, A340 the twin aisle Airbus at the beginning of its life cycle and
- Wide Body: A310, A300 the twin aisle Airbus in the second half of its life cycle.

As the top level organization is life cycle based, the internal organization of the product lines is as well.

Figure 3 shows that for the **product development phase** of a derivative, a small management group is built including technical, industrial and economical responsibility. This group works like a company in the company and manages the development centers and factories like a group of suppliers.

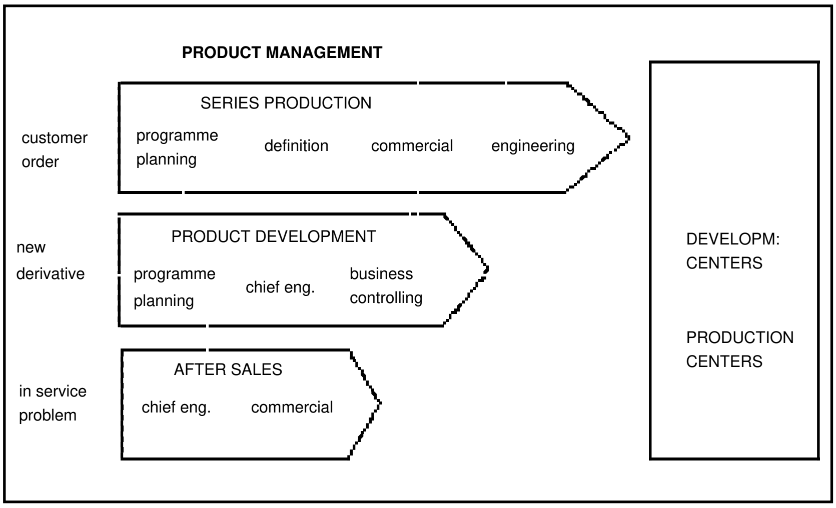

Fig. 3: Organisation of product management over life cycle

The **series production phase** was optimized following the guideline: Standardize as much as possible and then build an organization following the flow of the customer order. After standardization introducing catalogue items, the engineering functions were mainly assembly operations of existing solutions. The responsibility of a single engineer changed from a small highly sophisticated area to a broader view over several functions. The main advantage is that it is easier for him to foresee the influence of his decisions on the total path of a single customer. The earlier optimization for mean malfunctioning could be changed towards the optimization of each customer order.

The resulting organization (Fig. 3) included the engineering in the product management organization. So that in this case, only the factories are regarded at as suppliers.

The **after sales organization** has to handle spare parts and, most important for the organization, the technical problems found during the in-service period of the airplanes. As these problems are usually highly sophisticated by nature, the engineering specialits centers are in charge again and the product management takes the management task.

Each of the internal life cycle organizations exists as part of the so-called product management for the product line led by a single product manager (Figure 3).

Concurrent Engineering Concept for routine jobs

The above described organizational aspects for the engineering are part of a concurrent engineering concept for routine jobs which includes the functions:

1. Customer relation for orders/problems
2. Engineering
3. Customized procurement
4. Industrialization/production
5. Commercial

The implementation is done in two steps.

The **first step is a reduction of layers** in the hierarchy of the organization to overcome the inflexibilty and to increase the responsibility at the process level. In this environment, former department heads are functionally responsible over a broader range of functions (Fig. 4). Of course this is only likely to be successful if the number of people managed is regarded as more valuable than the functional project responsibility.

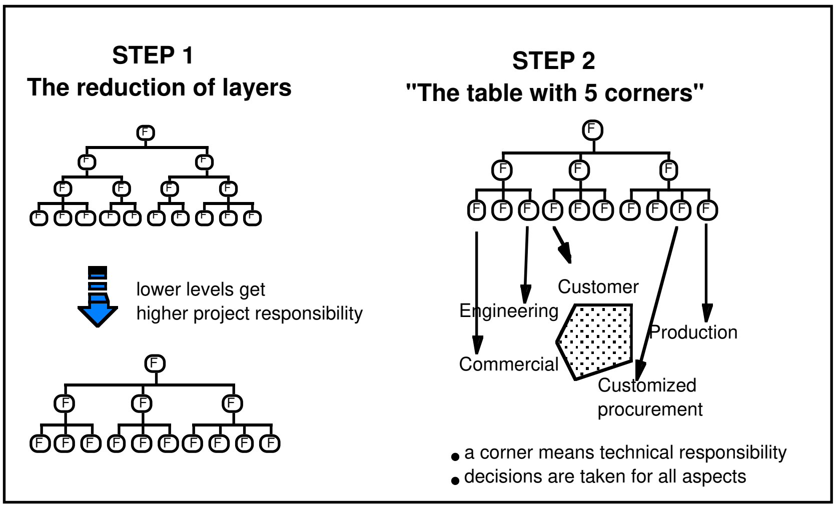

Fig. 4: The two step approach for concurrent engineering

The **second step** is very much comparable to the tiger team approach [Reddy et al. 93]. Due to the 5 involved functional disciplines we are placing around a table, we call it "The Table with 5 Corners" concepts (Fig. 4). With the title, we want to express, that

- decisions are taken including all relevant aspects for the customer order,
- each function has its own technical responsibility, i.e. corner and
- the availability is secured even for spontaneous questions.

Regarding the five layer concept of [Reddy et al. 93] we concentrated on the collaboration layer and the enterprise information model layer. For the collaboration layer we adopted methods used in the CIM computer integrated manufacturing field to reach common visibility of activities and data, planning and scheduling activities etc. This is possible because a shop floor responsible has a similar problem, i.e., to overlook a large number of functions and states, different directly and indirectly involved staff etc. However it is much more difficult to plan the process steps in the engineering environment. In scheduling terminology we have e.g. overlapping batch production and a large variance in lead time.

The information model layer is again defined from the life cycle phases. So there is an information model for the development phase, the series production and after sales. The main goal is to model technical, time and commercial aspects in relation to the product or a product oriented process step, which in this context, could e.g. mean an aircraft section to be transported to the final assembly line (Fig. 5).

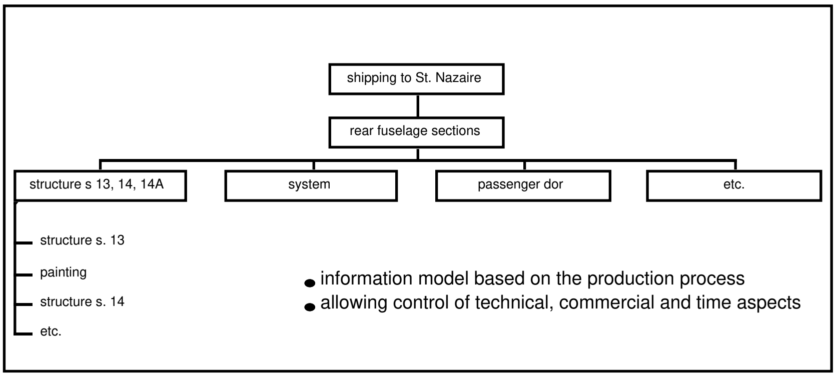

Fig. 5: The enterprise information model for series production (extremly simplified)

Economical concept for customer orientation with life cycle view

As the product management organization deals with specific problems over the life cycle, the solution for economical business processes does as well.

The economical concept for customer orientation will be described using a 3 phase view (Fig. 6), which is typical for high-tech companies.

Technological phase:
Typically in high-tech companies, the technological feasibility is the main driving factor, i.e. the development department has top priority. Cost/benefit analysis is mainly done after the development has been finished. Usually, major changes to the design were necessary to meet the budget limits (Fig. 7).

Problems:

- the technical solution lost its overall soundness due to top down budget reduction. During the realization phase, unplanned cost may finally reach the original budget overflow, because the basic technological approach is not changed,
- the customer view has only low priority, i.e., marketing and sales were only barely included in the product definition process and
- the life cycle cost has minor priority, the most important is the short term investment budget and the labor force needed for the development phase.

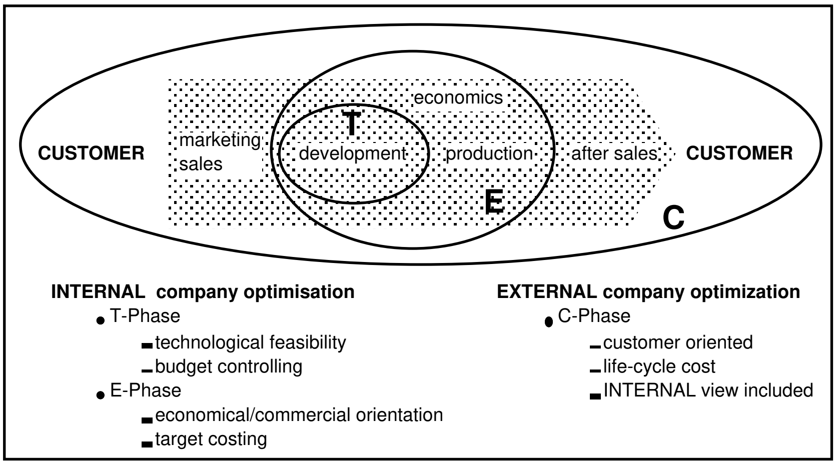

Fig. 6: From technological and economical orientation to customer orientation by adding the external view

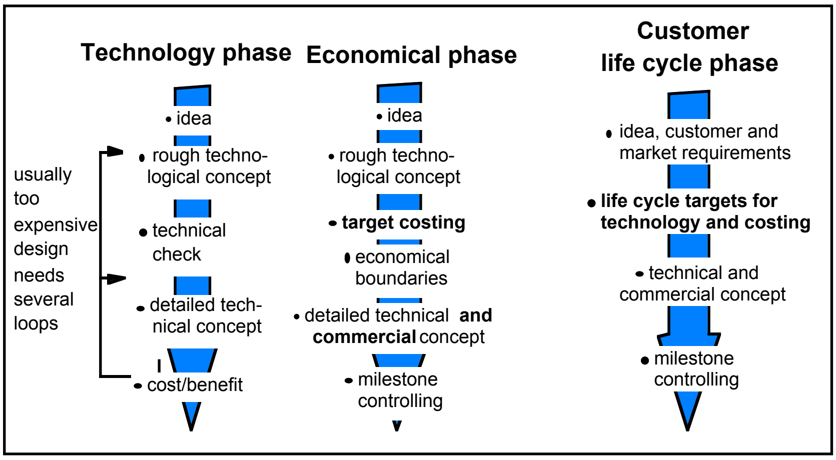

Fig. 7: Customer orientation with life cycle

Economical phase:

An unsatisfactory cost/benefit ratio may jeopardize the existence of the company. Usually, at that time, the priorities are changed drastically from technological to economical priorities. In this case, pure top down budget reduction is the first step. The problem is that development departments tend to give up their responsibilty.

To integrate the economical responsibility as a major part of decision making in the total organization mainly including the development departments, the concept of target costing has been introduced. Whereas the technological phase started with a cost/benefit analysis after the technological solution was already in a detailed state, the economical phase forces a target costing step after the rough technological concept (Fig. 7).

The results of this step are mainly economical boundaries. The technical staff has now the task to find a solution inside these boundaries. If the final concept is accepted, a milestone controlling starts at a high level of aggregation. This leaves the responsibility to project leaders for technical and economical decisions inside the boundaries.

Problem:

- The technological and the economical priority are both driven by an internal company view. High achievements in technological feasibility or cost reduction tend to hide possible negative impact on the customer satisfaction, i.e., a technological sound and/or low cost product is not automatically a success on the market.

Customer oriented phase:
The external view means looking from the customer into the company (Fig. 6). Marketing and sales get a new priority and have to be integrated in the product management decisions. The introduction of the whole life cycle view is the most important principle to ensure customer satisfaction and means for the costs to optimize:

- acquisition costs (e.g. development),
- operating and support cost (e.g. personnel, maintenance, replenishment spares) and
- disposal costs.

Maintenance costs and long term product quality have to be at least at the same priority level as the internal technological and cost reduction goals. As the early design decisions establish the major part of life cycle cost the principle has to be introduced from the beginning, ensuring that the typical trade-offs have been made to provide the best possible system at the lowest possible life cycle cost. Trade-off are e.g.:

- system/subsystem reliability and maintainability,
- design simplicity and
- design standardization.

The customer oriented process (Fig. 7) starts with customer and market requirements analysis from which the life cycle targets for technology and costing are derived. The following concept phase is now focussed on a product which tries to balance the external and internal optimization view of the business process.

Summary

This paper has presented a solution to business process reengineering and concurrent engineering concepts in the aerospace industry. The driving factor is the competitive market and the need for rigid profit orientation in globally oriented enterprises like Daimler-Benz Aerospace Airbus.

Using organization theoretical results, the main focus has been placed on structure and control to reduce complexity and to enable the organization to deal with uncertainty. The business process models derived centralize management tasks around order fulfillment for a product line while at the same time operational tasks are distributed.

The main structuring criterion is the product life cycle. Each phase from product development, series production to after sales has its own degree of distributed operationalization of processes. In the case of series production, standardization allows the integration of routine engineering tasks in the management organization called product management. The integration concept proposed considers the layered approach for concurrent engineering including an enterprise model for technical as well as commercial aspects.

The new orientation in economical optimization is towards the minimization of life cycle cost from an external customer view. Thus avoiding the drawbacks of pure technological or economical internal company optimization. This ensures that commercial thinking is integrated in the business process of product engineering.

The forthcoming challenges are in the adoption of the information systems in the new organization allowing new concepts for concurrent engineering like European concurrent development of the next Airbus generation with our Airbus Industrie partners.

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